

# ***Revolutionary Aeropropulsion Concepts Project***

Leo A. Burkardt

[Leo.a.burkardt@grc.nasa.gov](mailto:Leo.a.burkardt@grc.nasa.gov)

(216) 977-7021

John H. Glenn Research Center  
Lewis Field

November 16, 2000

**Glenn Research Center**

Aerospace Propulsion and Power Program

at Lewis Field



# Revolutionary Aeropropulsion Concepts Project

## Goal

Provide Balanced Investments in Aeropropulsion Technology Research to Aggressively Pursue Revolutionary Aeropropulsion Concepts Capable of 2x Payload-Range for Commercial and Military Aircraft, Enabling Point-to-Point Air Travel with Near Zero Emissions Capability, Leading to New, High Performance Aircraft and Air Breathing Space Transportation Systems

## Approach

- > Push technology barriers, enable breakthroughs, investigate unconventional systems
- > Develop sustained, long-term relationship with university community and innovative commercial partnerships with industry to foster and stimulate technology innovations and exploit advanced technology breakthroughs
- > Build on and enhance GRC's strong Core Competency and innovative research in Aeropropulsion and Aerospace Power
- > Apply integrated propulsion system analyses, supported by risk/safety/performance analyses to assess high payoff concepts, and to identify technology barriers, research needs, and steps toward technology maturation
- > Seek and identify further technology maturation opportunities, such as REVCON, Flight Research R&T and future Focused Research Efforts throughout the Project

**Glenn Research Center**

Aerospace Propulsion and Power Program

at Lewis Field



**Enable Mobility  
Revolution**

## ***Aeropropulsion Vision***

**Quantum  
Improvements in  
Performance and  
Emissions**

Manufacturing Base  
Infrastructure  
Revolution

Alternate Energy and Power Generation  
*(Fuel Cells, Ultra High Energy Power Sources)*

Near Zero  
Emissions, Non  
Gas Turbine

Fuel Infrastructure  
Revolution

Alternate Fuels

High Energy, Low  
Emissions

Engine  
Architecture  
Revolution

Smart Operations and Architecture Concepts  
*(New Millennium High Mach Propulsion,  
Unconventional Propulsion Cycles)*

2x Payload-Range &  
Point to point mobility

Gas Turbine  
Revolution

Extremely Efficient Engine  
Technologies

1.25x Fuel Efficient  
Gas Turbine

*Revolutionary Aeropropulsion  
Concepts Investment Areas*

### **University Collaboration**

*Nano Technology --- Aeropropulsion --- Information Technology*

# Revolutionary Aeropropulsion Concepts

## Example Concepts

*Quantum Improvement in  
Performance & Emissions*

Fuel Cells

Super  
Batteries

Alternate  
Fuels

Mini  
Engines

Variable,  
Adaptive  
Cycles

*Enabling*

## Non-traditional Propulsion/Power Systems

Electric  
Propulsion

Multi Cycle  
Engines

Distributed  
Propulsion  
Systems

Hybrid  
Propulsion

Variable  
Capability  
Engines

Mobility Enabled by 2x  
Payload-Range and Near  
Zero Emissions

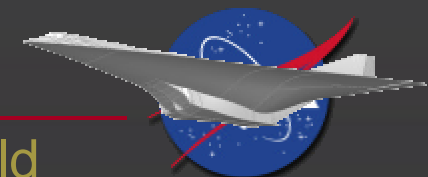


*A/C Impact*

**Research**

in Propulsion and Power

at Lewis Field



# Investment Area 1: New Millennium High Mach Propulsion High Mach Point-to-Point and Global Access

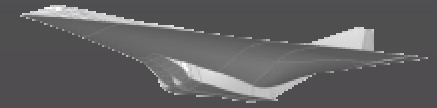
## Barrier Technologies

- Intelligent, adaptive structures
- Miniature sensors and actuators
- Light weight materials and structures
  - high temperature
  - high durability (commercial life)
- Alternate Fuels for high thrust-to-weight
  - high energy density additives such as nano particulates and derivatives
  - high hydrogen-to-carbon synthetic fuels
  - gelled propellants
- Validated, high fidelity thermal/aerodynamic modeling
  - Transonic
  - turboram take-over
  - transition to scramjet
  - turbulence, cooling, fuel/air mixing, inlet-turboramjet-scramjet mode transitioning

*Supersonic Bizjet*



*Global Access Vehicle*



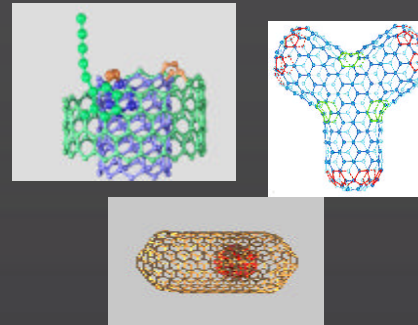
*Ceramic Combined Cycle*



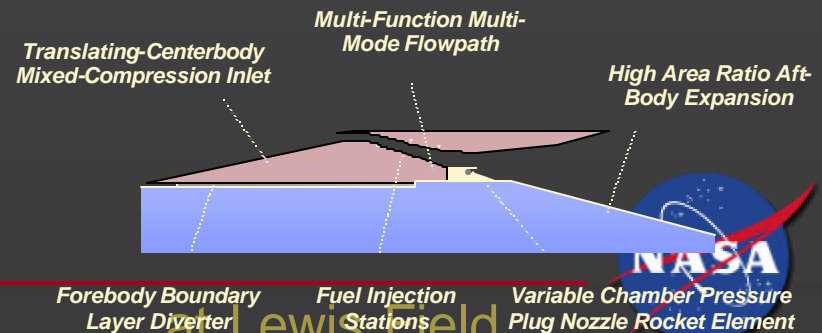
*Advanced Fuel*



*Nano Materials and Structures*



*Ramjet Flowpath to Optimized Combined Cycle Performance*



## Glenn Research Center

Aerospace Propulsion and Power Program

at Lewis Field

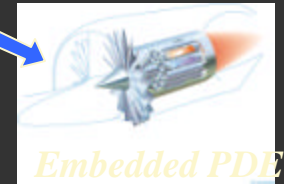
## Investment Area 2: Unconventional Propulsion Cycles Revolutionary Architecture and Operations

### Barrier Technologies

- Intelligent, adaptive structures
- Miniature sensors and actuators
- Light weight rugged materials and structures for high thrust to weight and long durability (commercial life)
- Validated, high fidelity modeling of unconventional systems
- Low cost extremely low emissions combustion systems



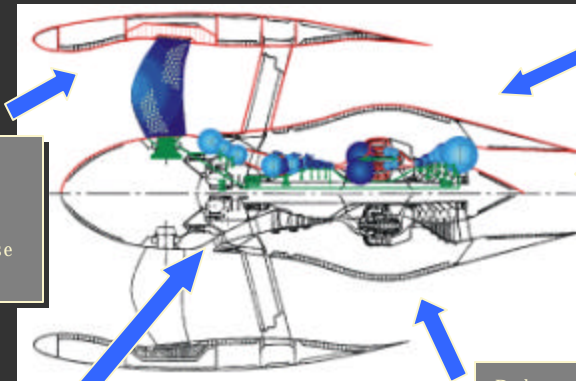
*Mini Engines*



*Embedded PDE  
Combustion*

### **Distributed or Hybrid Propulsion Systems**

Ultra simple, small, high performance core with high reliability and operability enabling innovative propulsion/airframe integration (e.g. mini engines, multi-fanned cores, high aspect ratio nozzles, topping & combined cycle hybrid propulsion)



Flow control and smart structures for nacelle & blade shape morphing yielding take-off & cruise opt. Noise/perf/emiss.

Flow control blading yielding PR mods for peak cycle efficiency

Fluidic nozzle area control coupled with active noise suppression

### **Variable Area Hot Section**

### **Off-Axes Core**

Highly variable geometry LPC and adaptable gearbox for fan/core rematching

Robust common military/commercial core, staged & inter-turbine combustors for take-off & cruise re-optimization of perf/emiss.

### **Variable Capability Engine**

Advanced propulsion technologies that enable modification of engine cycle characteristics to meet diverse mission requirements without severe geometry changes, enabling adaptive cycle operation across entire mission for optimal performance & minimal emissions. Characteristics of a variable capability engine:



# Investment Area 3: Non-Turbomachinery Based Components Emissionless Propulsion

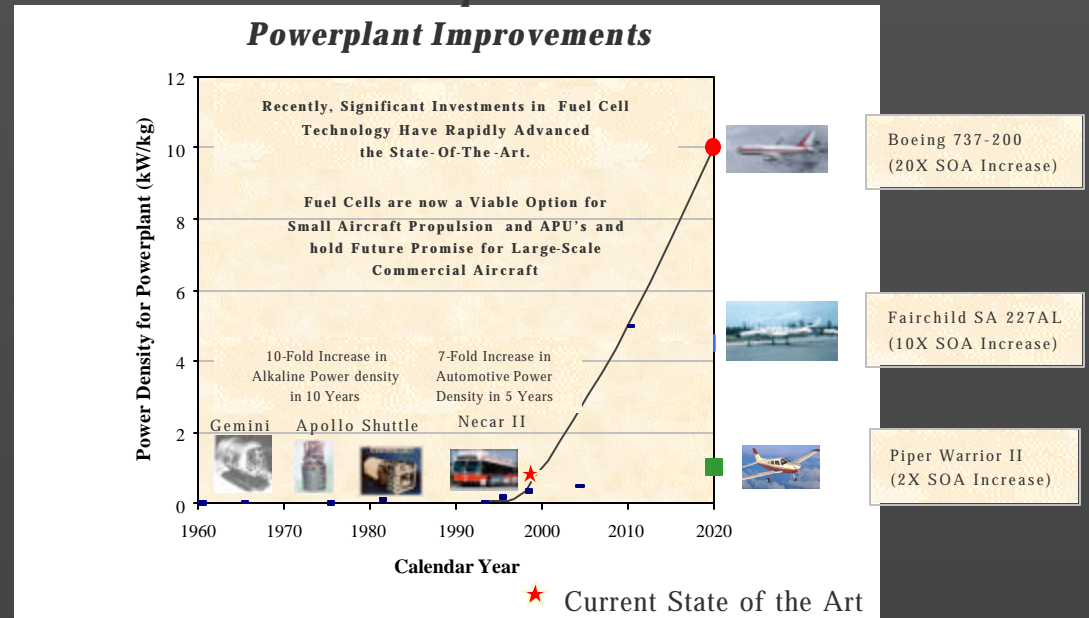
## Barrier Technologies

- Light weight, corrosion resistant materials
- Innovative Fuel Cell Stack
  - Anode/Electrolyte/Cathode optimization
  - Components for High Power Density (2x - to 20x improvement)
- Highly efficient motors (e.g. superconductivity motor)
- Integrated Miniaturized Power Distribution Systems
- Ultra High Energy Density (10-100x) Power Sources

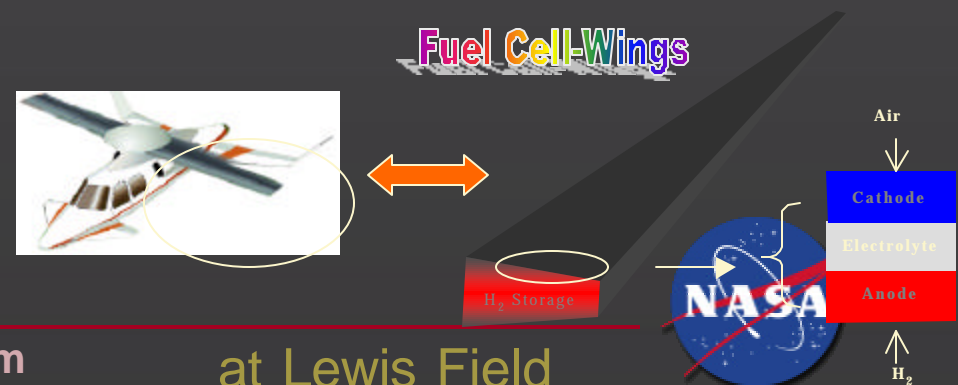
**Glenn Research Center**

Aerospace Propulsion and Power Program

## *Recent and Anticipated Fuel Cell Powerplant Improvements*

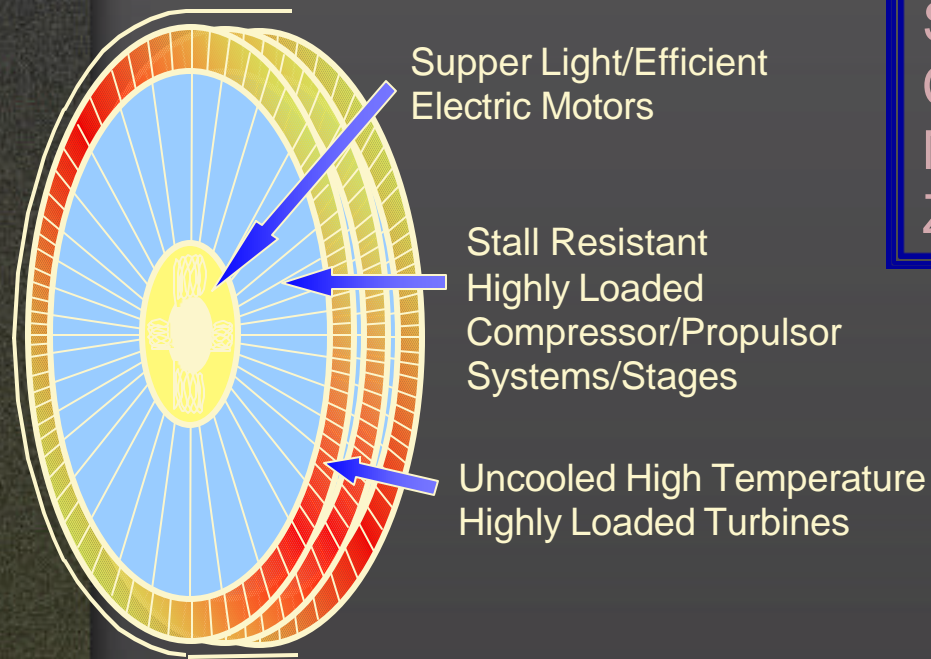


*Example: Integrated Systems Combine Power Production  
with Aircraft Structure  
(Fuel Cell + Reactant Storage + Wing)*



at Lewis Field

# Configurable, Modular, Highly Integrated Propulsion



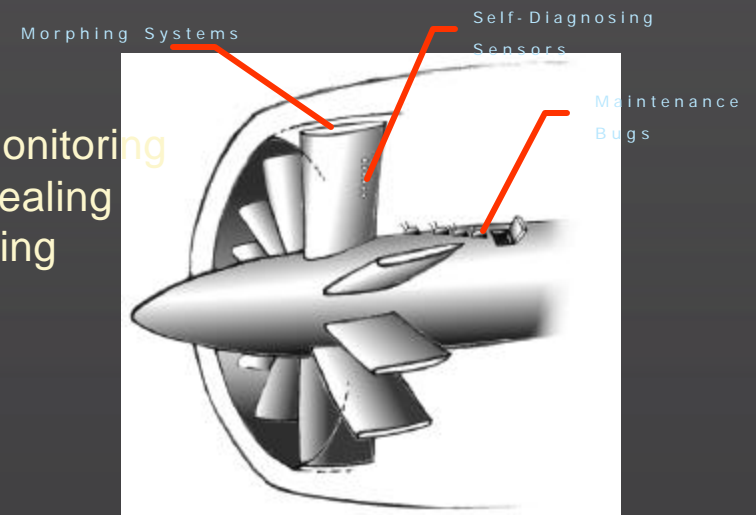
- Multiple stages stacked as necessary
- Each stage self contained, speed independent
- Configurations, Modes of Operation
  - > ZEV - Electric drive only
  - > Combustion assisted with electric cruise
  - > Heat engine
    - Advanced combustor/fuel
    - In-stage combustion

**Glenn Research Center**

Aerospace Propulsion and Power Program

Simple, Building Block Approach  
Cost Efficient  
Maximum Fuel Efficiency  
Zero to Near Zero Emissions

Self-Monitoring  
Self-Healing  
Morphing



Highly Integrated

- Propulsion Systems
- Propulsion/Airframe

